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SUBJECT: Preliminary Analysis of Traverse Capabilities for a Possible Apollo 15 Mission to Hadley-Apennines
Cases 320 and 340

DATE: July 27, 1970

FROM: P. Benjamin
J. W. Head

ABSTRACT

A preliminary analysis is carried out of traverse capabilities for a possible Apollo 15 mission to Hadley-Apennines, one of the candidate landing sites for Apollo 15. Objectives of a mission to this site include the sampling of Apenninian material and examination and sampling of the rim of the sinuous Hadley Rille and associated volcanic deposits. The traverses designed were limited by the system capability and hardware constraints projected for Apollo 15. The following hardware and operational options were analyzed:

1. -6 PLSS
2. -7 PLSS, ALSEP on EVA 1
3. -7 PLSS, ALSEP on EVA 2
4. -7 PLSS, ALSEP on EVA 1, 7 hr limit for EVA 1
5. -7 PLSS, ALSEP on EVA 2, 7 hr limit for EVA 1
6. J mission timeline, -7 PLSS, LRV

Increased hardware capabilities (time, range of operations) yielded progressively more ambitious traverses from the designated landing point, although the north-south trending Apennine Front was never reached. Assessment of the ability to achieve the scientific objectives at this site showed a corresponding trend.

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MEMORANDUM FOR FILE

INTRODUCTION

Early consideration of the spectrum of landing sites available for Apollo 15 showed that many were ineligible due to various operational constraints (1). This memorandum represents a preliminary analysis of traverse capabilities for a possible Apollo 15 mission to Hadley-Apennines, one of the candidate landing sites for Apollo 15. The landing point used and shown in Figure 1 is that under analysis by MSC for this site.

GEOLOGIC CHARACTERISTICS OF THE HADLEY-APENNINE SITE

Rima Hadley is a V-shaped lunar sinuous rille which parallels the Apennine Mountain Front along the eastern boundary of Mare Imbrium. The rille originates in an elongate depression in an area of associated volcanic domes and generally maintains a width of about 1 km and a depth of 200 meters until it merges with a second rille approximately 100 km to the north. The origin of sinuous rilles such as Rima Hadley is enigmatic but is probably due to some type of fluid flow. The Apennine Mountains rise up to 2 km from the area of Rima Hadley and contain ancient material exposed during the excavation of the Imbrium basin.

Objectives of a mission to this site include the sampling of Apenninian material, which should provide very ancient rocks whose origin predates the formation and filling of the major mare basins, and examination and sampling of the rim of the sinuous Hadley Rille and associated volcanic deposits.

CONSTRAINTS

The traverses designed were limited by the system capability and hardware constraints projected for Apollo 15 and based upon previous flight experience. The constraints were coordinated with ASPO to assure a common working base for tradeoffs and analysis. It was assumed for all traverses that the astronaut would walk at 3.3 km/hr at a metabolic rate of 1200 Btu/hr over mare, and that walking speed would be reduced to 1.6 km/hr at the same metabolic rate when the rough terrain along the Apennine Front is traversed. The metabolic rate at sampling stations and for overhead activities was taken as 1050 Btu/hr.

Traverses were designed for both the -6 PLSS and -7 PLSS, since either may be available for the Apollo 15 mission. The usable quantities of consumables after provision for penalties, uncertainties and residuals are shown in Table 1. Leak rates assumed are also indicated. The reduced quantity of O_2 available for EVA 2 in the -7 PLSS is a result of incompatibility of the LM-9 recharge regulator and the design tank pressure for this PLSS. A 1/2 hour reserve of all consumables is also provided for. The feedwater residuals provide this capability, and .1 lb O_2 is reserved.

Overhead at the LM on H missions for EVA 1 is taken to be 2 hours, and 1-1/4 hours of overhead are used on EVA 2. ALSEP deployment, including the HFE, requires 2 hours. ALSEP deployment on EVA 1 or EVA 2 is considered. Both the 6 hour and 7 hour time limit on EVA 1 are considered with the -7 PLSS.

TRAVERSES

The seven sets of traverses shown in Figures 1 to 7 and summarized in Table 2 attempt to achieve the broad scientific objectives at this site using the various mission capabilities defined by the hardware and operational options. Tables 3 to 6 present the detailed times and distances for each traverse.

H-Mission, -6 PLSS, No. 1 - The first six sets of traverses assumed the use of H mission hardware (CSM 111, LM-9 no LRV). The first two of these are planned for the limited life support capability of the -6 PLSS. Both EVA's are limited by oxygen usage, and EVA 1 reaches an arbitrary time limit of 4-1/2 hours just as the oxygen limit is reached. On EVA 1, shown in Figure 2 and Table 3, sufficient time remained after ALSEP deployment for a ten minute traverse to an area within the smooth plains unit. Insufficient time was available to reach other units. In this example, EVA 2 was divided between the Apennine Ridge and the sinuous rille, with station times of fifteen and ten minutes respectively. These times are probably insufficient for proper geologic investigation of either objective.

H-Mission, -6 PLSS, No. 2 - The minimal time available at the primary objective, the Apennine Ridge, in the above traverses led to the construction of an alternate set of traverses shown in Figure 3 and Table 3 with the same hardware and operational options. EVA 2 concentrated on the Apennine Ridge at the expense of visiting the sinuous rille on this mission, and a more acceptable station time of 35 minutes was designated for investigation of the ridge. In addition, 15 minutes were spent at a large crater at the foot of the ridge.

H-Mission, -7 PLSS, ALSEP on EVA 1 - If a -7 PLSS is available for Apollo 15 it will supply an EVA 1 capability, fully charged, of more than 6 hours. Because of the very long day which results when EVA 1 is performed on touchdown day, this EVA has been limited, for J mission planning, to a length of 6 hours. This time constraint has been adopted for this set of traverses and limits the length of EVA 1. EVA 2 is constrained to less than 4 hours by the incomplete oxygen recharge. In this analysis, ALSEP is assumed to be deployed in the first portion of EVA 1, followed by a geology traverse. The traverses are described in Figure 4 and Table 4. Since the acquisition of material from the Apennine Ridge is the primary objective, investigation of this area was planned for the longer traverse time on EVA 2. EVA 1 was then concentrated on investigation of the rille, since dividing this EVA between the ridge and the rille would have provided inadequate station time at both points. EVA 2 concentrated on the ridge and divided 40 minutes between two stations there.

H Mission, -7 PLSS, ALSEP on EVA 2 - If ALSEP deployment is delayed until EVA 2 the entire time within the time constraint afforded by the fully charged -7 PLSS can be utilized on an EVA 1 traverse. This results in a more efficient use of travel time to provide increased station time for the full mission compared to the previous case. ALSEP deployment and overhead completely uses all time on EVA 2, eliminating any traverse. The EVA 1 traverse, as indicated in Figure 5 and Table 4, was therefore arranged so that the most important objectives could be visited on this single EVA. One station was planned for a scarp or rille area located near the Apennine Ridge and two stations (totaling 45 minutes) were allocated to investigation of the ridge itself. The sinuous rille was visited for 30 minutes on the return traverse to the LM.

H Mission, -7 PLSS, ALSEP on EVA 1, 7:00 limit - If a long touchdown day were found to be acceptable or a sleep before EVA timeline were adopted, it may be possible to use the full capability of the -7 PLSS on EVA 1 by relieving the time constraint. A 7 hour limit results in water being the constraining consumable in EVA 1 and oxygen limiting EVA 2. The increased time enables more stations to be planned and a wider sampling of the Apennine Ridge area to be made, as shown in Figure 6 and Table 5. In particular, EVA 2 can now reach the ridge and have sufficient time remaining for a more reasonable station time. This provides one Apennine Ridge station on EVA 2 and two on EVA 1, for a total station time at the ridge of 50 minutes. In addition, the rille is visited on EVA 2 and the smooth plains scarp on EVA 1.

H Mission, -7 PLSS, ALSEP on EVA 2, 7:00 limit - Once again, delaying ALSEP deployment until EVA 2 results in the elimination of a traverse in that EVA but a more efficient use of travel time in EVA 1 for an increase in overall scientific return for the mission. For this set of traverses, as shown in Figure 7 and Table 5, the increased time is invested in an additional station at the rille and a station at the contact between the mare and the smooth plains material. A possible alternative to these two additional stations might be to spend an additional 40 minutes at the Apennine Ridge using the traverse outlined in Figure 5.

J Mission, -7 PLSS, LRV - This final case compares the H mission capability as described by the options above to the considerably greater exploration capability afforded by the LRV and one 6 hour and two 7 hour EVA's planned for a J mission. The short duration EVA 1 traverse is directed towards a single station at the base of the Apennine Ridge. The EVA 2 traverse concentrates on the sinuous rille, where it visits two areas of bedrock exposure, and on the rugged domes and domical hills associated with the mare surface. EVA 3 explores the Apennine Ridge south of the landing area and also investigates the sinuous rille and several domes and hills in that region.

Alternatively, EVA 2 could concentrate on the east-west trending Apennine Ridge area to the southeast of the landing site. This would result in a deemphasis of rille investigation and an increased emphasis on the Apennine Ridge for the total mission. Since the north-south trending part of the Apennine Front lies 9 km from the landing area at its nearest point, a traverse to this point would result in a very limited amount of time at that station, and virtually no time for further investigation of the north-south trending front.

CONCLUSIONS

Increased hardware capabilities (time, range of operations) yield progressively more ambitious traverses from this landing point, although the north-south trending Apennine Front is never reached. Assessment of the ability to achieve the scientific objectives at this site shows a corresponding trend. The scientific merit of the traverses is more dependent on the particular landing point chosen and results of previous Apollo missions than it is on the changes in capabilities at this particular landing point.

2032-PB-meh
2015-JWH-meh

P. Benjamin

J. W. Head

REFERENCE

1. N. W. Hinners, "Subgroup Meeting of June 5, 1970," memo to GLEP Site Selection Subgroup Distribution, June 10, 1970.

FIGURE 1 - HADLEY-APENNINE REGION

TABLE 1

H MISSION USABLE PLSS CAPACITY

		-6 PLSS (LBS)	-7 PLSS (LBS)	LEAK RATE (LBS/HR)
H_2O	EVA 1	7.57	10.04	0
	EVA 2	7.57	10.04	.1
O_2	EVA 1	.88	1.34	0
	EVA 2	.88	.84	.02

TABLE 2

TRAVERSE SUMMARY

	TRAVEL DISTANCE (KM)	TRAVEL TIME	STATION TIME	OVERHEAD TIME	LIMIT
H Mission, -6 PLSS, No. 1:					
EVA 1	1.0	0:20	0:10	4:00	time/O_2
EVA 2	6.0	2:10	0:25	1:15	O_2
H Mission, -6 PLSS, No. 2:					
EVA 1	1.0	0:20	0:10	4:00	time/O_2
EVA 2	4.0	1:45	0:50	1:15	O_2
H Mission, -7 PLSS, ALSEP on EVA 1:					
EVA 1	5.0	1:30	0:30	4:00	time
EVA 2	4.1	1:45	0:40	1:15	O_2
H Mission, -7 PLSS, ALSEP on EVA 2:					
EVA 1	6.4	2:35	1:25	2:00	time
EVA 2	0.0	0:00	0:00	3:15	O_2
H Mission, -7 PLSS, ALSEP on EVA 1, 7:00 Limit:					
EVA 1	4.5	1:55	0:45	4:00	H_2O
EVA 2	4.9	1:45	0:45	1:15	O_2
H Mission, -7 PLSS, ALSEP on EVA 2, 7:00 Limit:					
EVA 1	6.9	2:50	1:50	2:00	H_2O
EVA 2	0.0	0:00	0:00	3:15	O_2
J Mission, -7 PLSS, LRV:					
EVA 1	4.5	0:35	0:25	5:00	time
EVA 2	19.0	2:20	3:10	1:30	time
EVA 3	16.6	2:03	2:50	1:45	H_2O

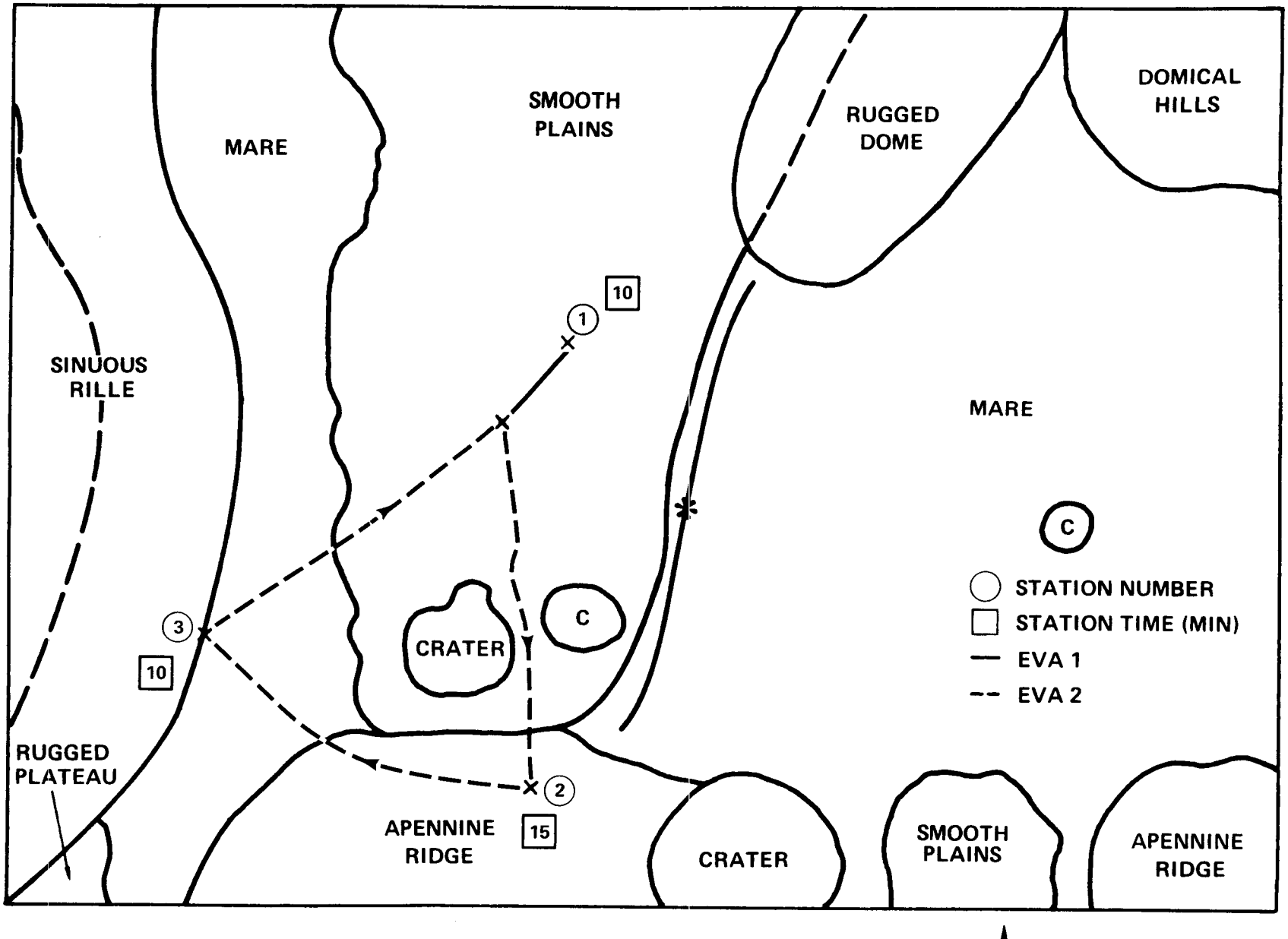

FIGURE 2 - H MISSION, -6 PLSS, NO. 1
GEOLOGIC MAP OF PART OF THE HADLEY-APENNINES REGION
BY F. EL-BAZ

TABLE 3

HADLEY - APENNINES TRAVERSES

	FROM	TO	DISTANCE (KM)	TIME
H Mission, -6 PLSS, No. 1				
EVA 1	LM	1	.5	0:10
				0:10
	1	LM	.5	0:10
			1.0	0:30
EVA 2	LM	2	2.0	0:53
				0:15
	2	3	2.0	0:41
				0:10
	3	LM	2.0	0:36
			6.0	2:35
H Mission, -6 PLSS, No. 2				
EVA 1	LM	1	.5	0:10
				0:10
	1	LM	.5	0:10
			1.0	0:30
EVA 2	LM	2	2.0	0:53
				0:35
	2	4	1.0	0:35
				0:15
	4	LM	1.0	0:17
			4.0	2:35

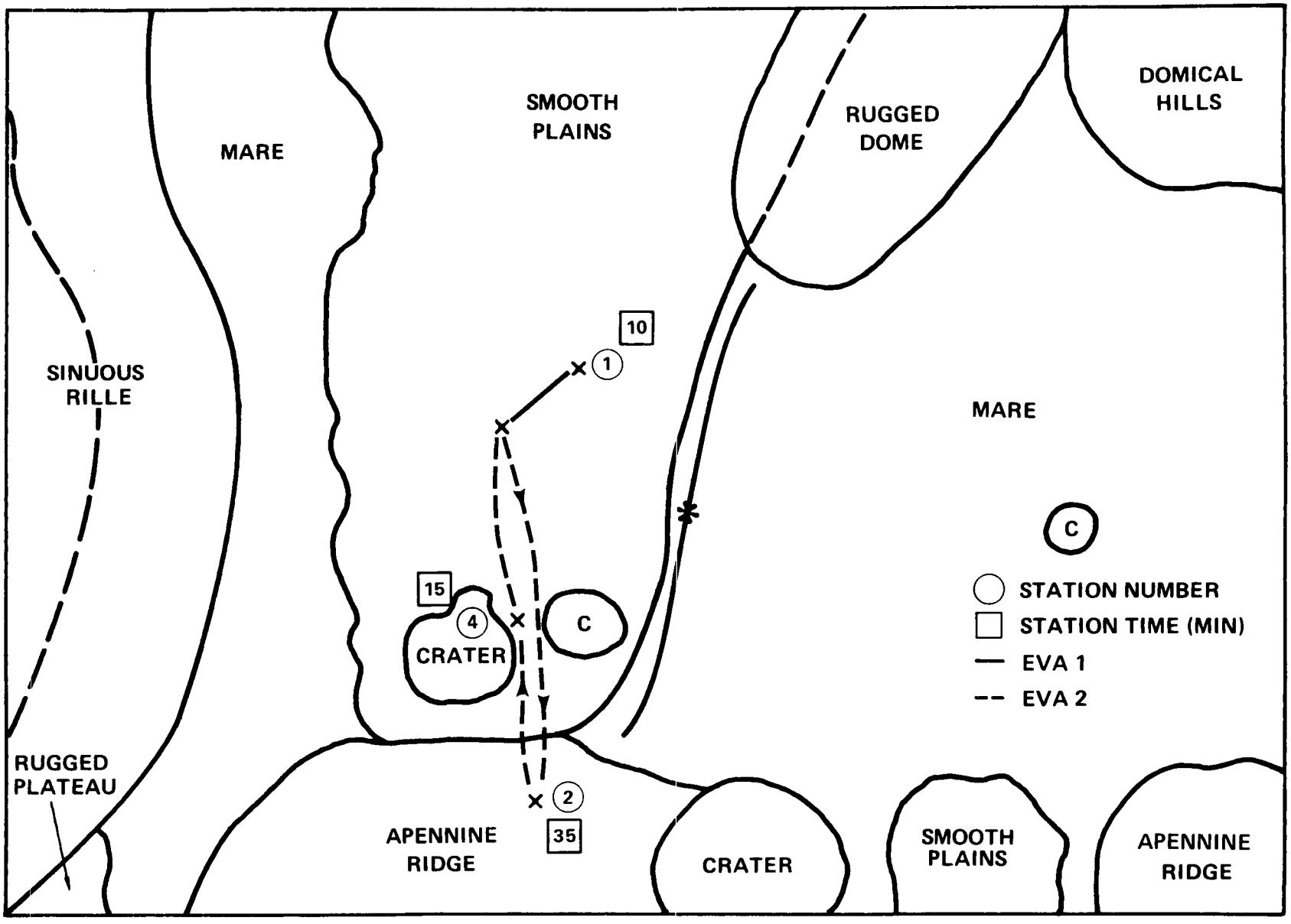

FIGURE 3 - H MISSION, –6 PLSS, NO. 2
GEOLOGIC MAP OF PART OF THE HADLEY-APENNINES REGION
BY F. EL-BAZ

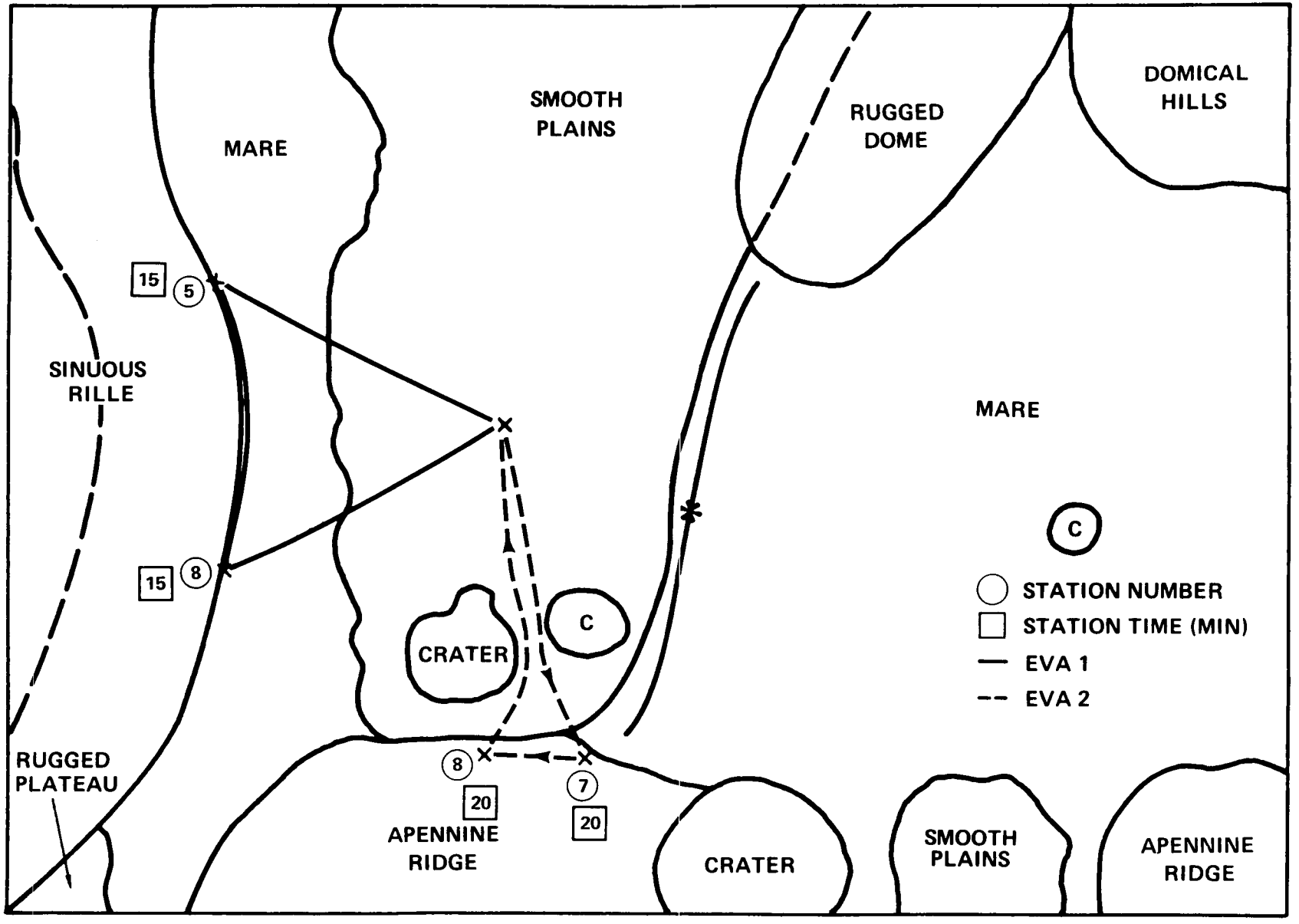

FIGURE 4 - H MISSION, –7 PLSS, ALSEP ON EVA 1
GEOLOGIC MAP OF PART OF THE HADLEY-APENNINES REGION
BY F. EL-BAZ

TABLE 4

HADLEY - APENNINES TRAVERSES

	FROM	TO	DISTANCE (KM)	TIME
H Mission,-7 PLSS,ALSEP on EVA 1				
EVA 1	LM	5	1.7	0:31
				0:15
	5	6	1.6	0:28
				0:15
	6	LM	1.7	0:31
			5.0	2:00
EVA 2	LM	7	1.8	0:43
				0:20
	7	8	0.5	0:19
				0:20
	8	LM	1.8	0:43
			4.1	2:25
H Mission,-7 PLSS,ALSEP on EVA 2				
EVA 1	LM	9	1.5	0:25
				0:10
	9	2	.8	0:30
				0:30
	2	10	1.0	0:38
				0:15
	10	3	1.1	0:26
				0:30
	3	LM	2.0	0:36
			6.4	4:00
EVA 2	ALSEP only			

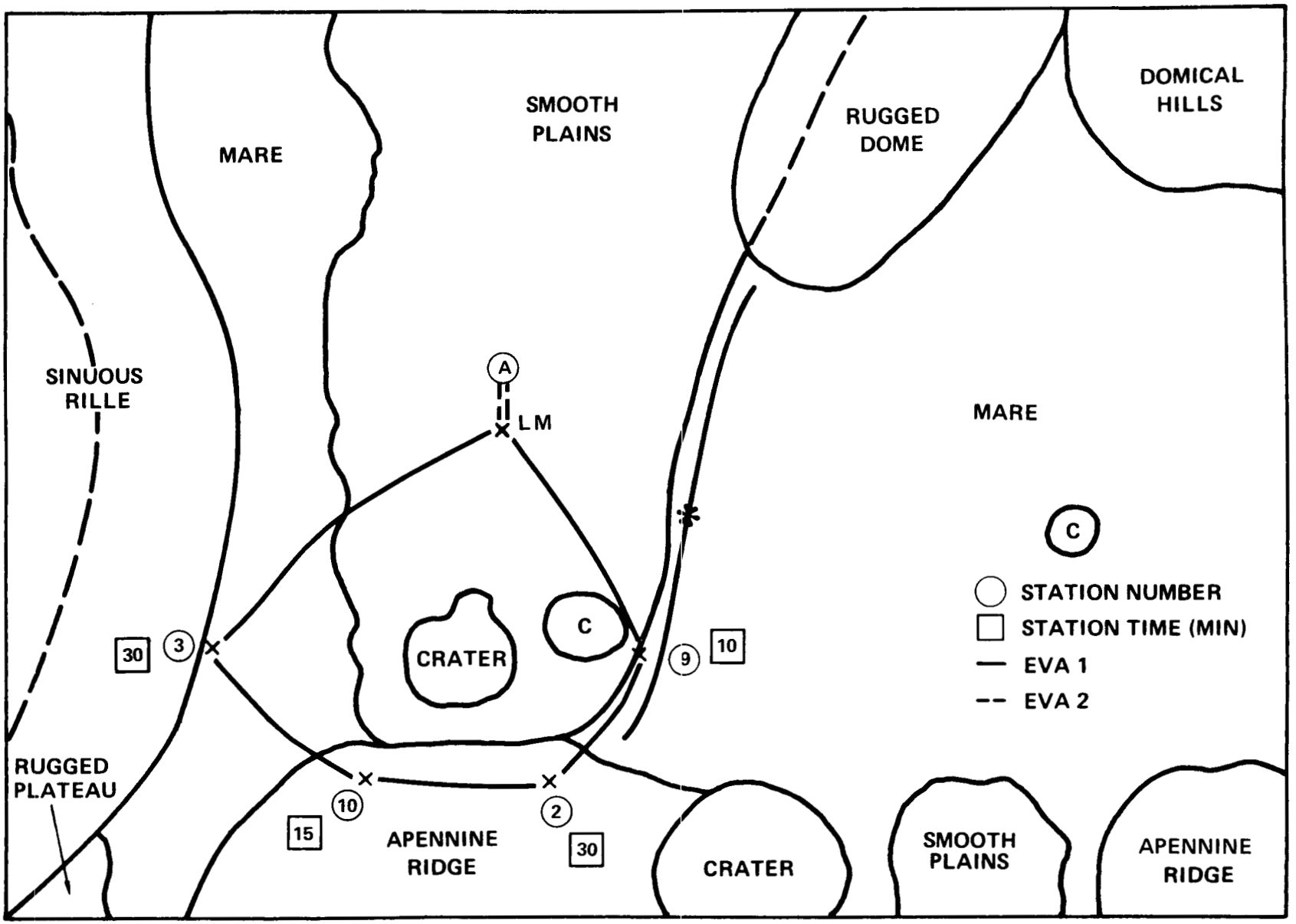

FIGURE 5 - H MISSION, –7 PLSS, ALSEP ON EVA 2
GEOLOGIC MAP OF PART OF THE HADLEY-APENNINES REGION
BY F. EL-BAZ

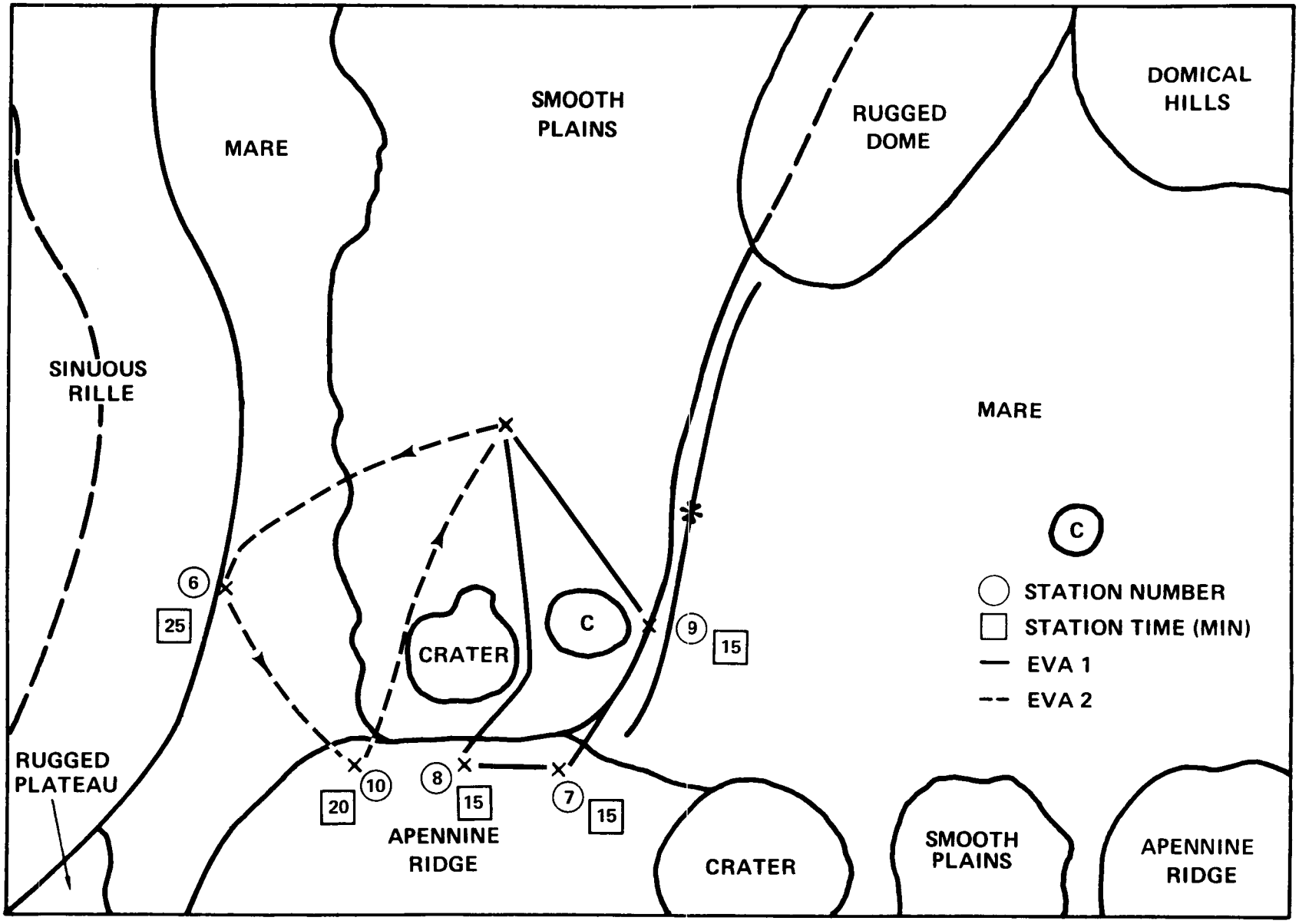

FIGURE 6 - H MISSION, –7 PLSS, ALSEP ON EVA 1, 7:00 LIMIT
GEOLOGIC MAP OF PART OF THE HADLEY-APENNINES REGION
BY F. EL-BAZ

TABLE 5

HADLEY - APENNINES TRAVERSES

	FROM	TO	DISTANCE (KM)	TIME
H Mission, -7 PLSS, ALSEP on EVA 1, 7:00 Limit				
EVA 1	LM	9	1.5	0:25
				0:15
	9	7	.7	0:28
				0:15
	7	8	0.5	0:19
				0:15
	8	LM	1.8	0:43
			4.5	2:40
EVA 2	LM	6	1.8	0:33
				0:25
	6	10	1.2	0:26
				0:20
	10	LM	1.9	0:46
			4.9	2:30
H Mission, -7 PLSS, ALSEP on EVA 2, 7:00 Limit				
EVA 1	LM	9	1.5	0:25
				0:10
	9	2	.8	0:30
				0:30
	2	10	1.0	0:38
				0:15
	10	3	1.1	0:26
				0:30
	3	3a	1.1	0:26
				0:15
	3a	3b	.5	0:09
				0:10
	3b	LM	.9	0:16
			6.9	4:40

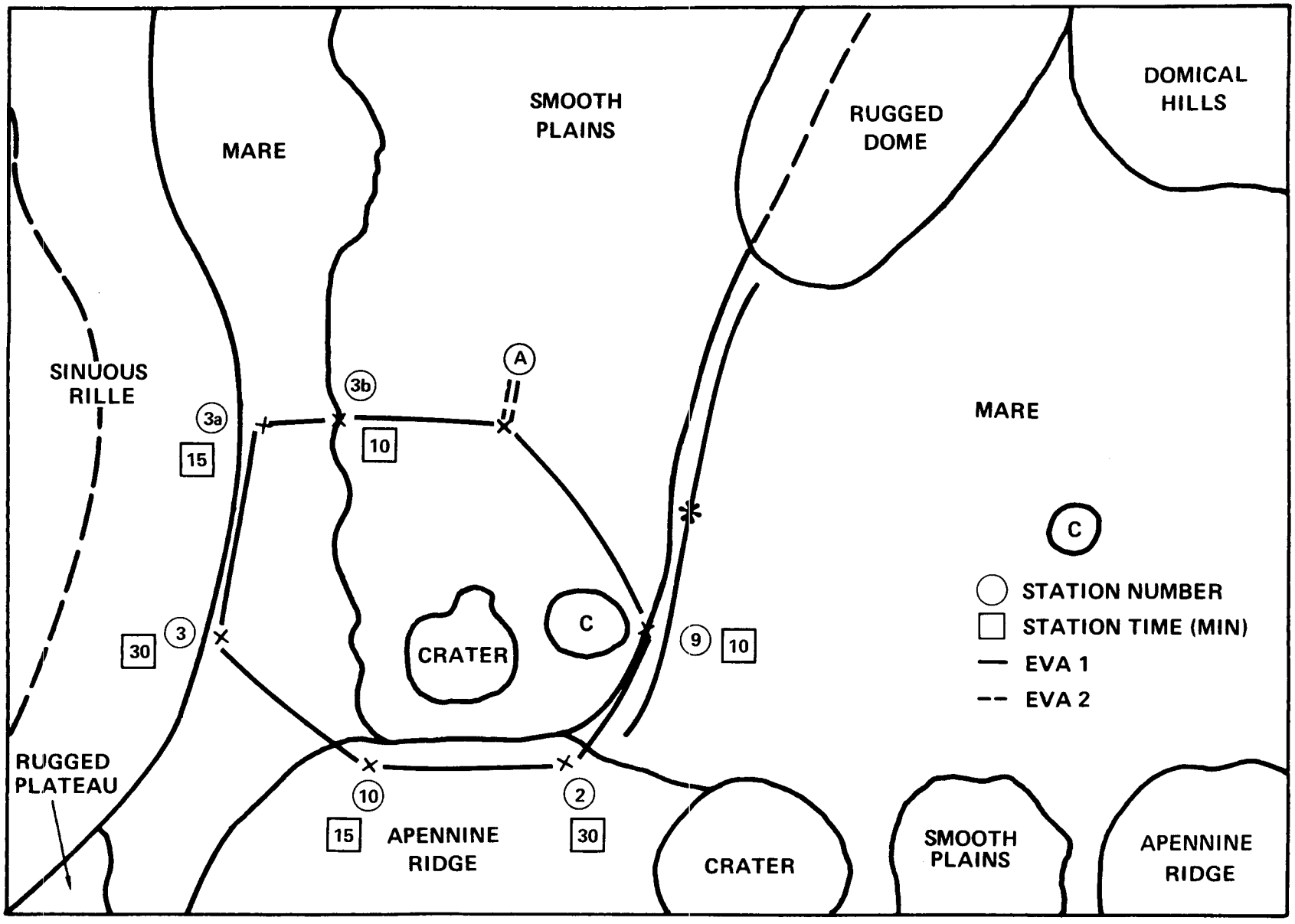

FIGURE 7 - H MISSION, –7 PLSS, ALSEP ON EVA 2, 7:00 LIMIT
GEOLOGIC MAP OF PART OF THE HADLEY-APENNINES REGION
BY F. EL-BAZ

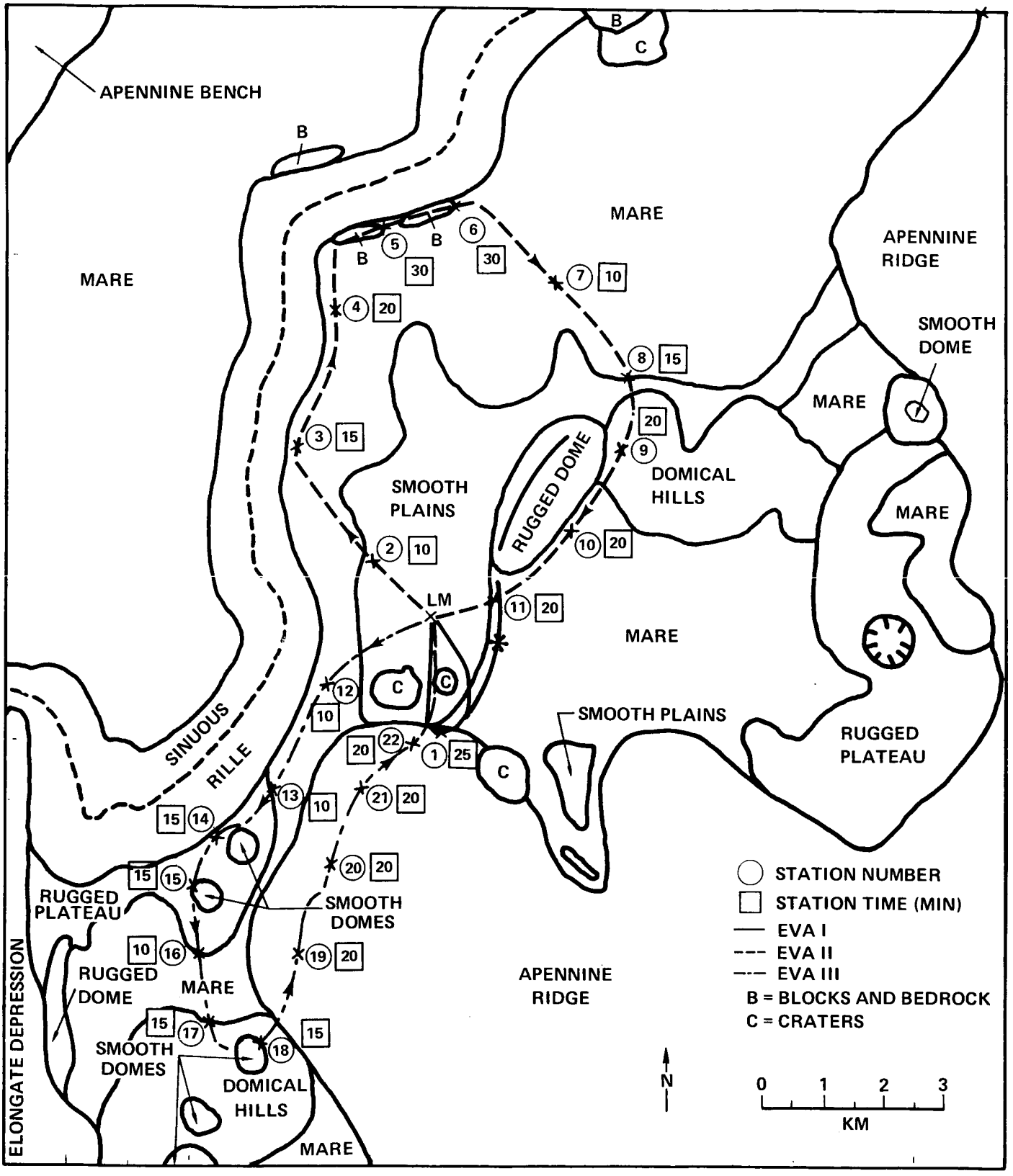

FIGURE 8 - J MISSION, –7 PLSS, LRV
GENERALIZED GEOLOGIC MAP OF THE HADLEY-APENNINES
REGION AFTER F.EL-BAZ

TABLE 6
HADLEY - APENNINES TRAVERSES

	FROM	TO	DISTANCE (KM)	TIME
J Mission,-7 PLSS,LRV				
EVA 1	LM	1	2.5	0:20
				0:25
	1	LM	2.0	0:15
			4.5	1:00
EVA 2	LM	2	1.2	0:09
				0:10
	2	3	2.5	0:19
				0:15
	3	4	2.3	0:17
				0:20
	4	5	2.4	0:18
				0:30
	5	6	1.3	0:10
				0:30
	6	7	1.8	0:13
				0:10
	7	8	2.0	0:15
				0:15
	8	9	1.4	0:10
				0:20
	9	10	1.5	0:11
				0:20
	10	11	1.6	0:12
				0:20
	11	LM	1.0	0:06
			19.0	5:30
EVA 3	LM	12	2.0	0:15
				0:10
	12	13	1.6	0:12
				0:10
	13	14	1.5	0:11
				0:15
	14	15	0.8	0:06
				0:15
	15	16	1.0	0:07
				0:10
	16	17	1.1	0:08
				0:15
	17	18	1.0	0:07
				0:15
	18	19	1.5	0:11
				0:20
	19	20	1.6	0:12
				0:20
	20	21	1.2	0:09
				0:20
	21	22	1.3	0:10
				0:20
	22	LM	2.0	0:15
			16.6	4:53

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